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Brief Communication

Selection of response criteria affects the success rate of oral appliance treatment for obstructive sleep apnea

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ABSTRACT

Background: In oral appliance therapy for obstructive sleep apnea (OSA), treatment success is arbitrarily defined. We investigated if the selection of response criteria affected the success rate of oral appliance treatment.

Methods: The effects of an oral appliance on apnea–hypopnea index (AHI) and nadir percutaneous oxygen saturation (SpO_2) were investigated in 224 OSA patients. Treatment success was defined as a reduction in AHI to <5 events per hour with a >50% reduction in baseline AHI (criterion 1), a follow-up AHI of <10 events per hour with a >50% reduction in baseline AHI (criterion 2), a >50% reduction in baseline AHI alone (criterion 3), or a >50% reduction in baseline AHI with the nadir SpO_2 above 90% (criterion 4).

Results: The baseline AHI was reduced with an oral appliance in place compared with the follow-up value (23 ± 11–8.5 ± 8.7 events/h; $P < .05$) in all of the participants. In every OSA subgroup, the success rate under criterion 3 (75% [mild], 71% [moderate], and 70% [severe]) was greater than that under criterion 1 (53%, 40%, and 24%, respectively). However, responders under criterion 3 in the severe OSA subgroup were still hypoxemic with a nadir SpO_2 of 87 ± 8% even after treatment. This situation was improved by the use of criterion 4, in which a satisfactory improvement in AHI (from 38 ± 11 to 1 ± 1 events/h; $P < .01$) was associated with a sufficient increase in the nadir SpO_2 (93 ± 2%).

Conclusions: We conclude that the selection of response criteria influences the success rate of oral appliance treatment. To avoid adverse health outcomes, an adjunct definition of treatment success using SpO_2 may be effective for patients who have more severe OSA.

1. Introduction

Oral appliances that advance the mandible forward are now indicated for mild to moderate obstructive sleep apnea (OSA) [1–3]. However, one clinical issue in oral appliance therapy is that different studies have used different criteria for treatment success [2,3]. The most common definitions of treatment success include a reduction in the apnea–hypopnea index (AHI) to <5 events per hour or <10 events per hour in addition to a >50% reduction in baseline AHI [2–28]. A >50% reduction in baseline AHI alone, post-treatment AHI <15 events per hour, and a reduction in AHI to <20 events per hour also have been used [2–28]. Among these, the most stringent definition of success is a reduction in the AHI to less than 5 events per hour in conjunction with a >50% reduction in AHI at baseline, which generally can be achieved by nasal continuous positive airway pressure. In contrast, a more liberal definition such as a reduction of 50% or more from the baseline AHI often is used for oral appliance therapy and for other treatments [2,3,29,30].

Although a treatment may be regarded as successful under the liberal definition of a response, an increase in residual respiratory events after treatment could possibly lead to adverse health outcomes. Moreover, no previous report has considered the role of the oxygenation level in evaluating the treatment outcome in oral appliance therapy. The effects of the response criteria on clinically relevant treatment outcome need to be more carefully defined from a risk–benefit perspective. Hence we first investigated if the success rate of treatment with an oral appliance would considerably vary with the selection of the response criteria in our study. Next, we sought to identify clinically relevant criteria for treatment success with oral appliances by focusing on AHI and oxygenation.

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2. Methods

The protocol of our investigation was approved by the ethics committee of the Neuropsychiatric Research Institute, Tokyo, Japan. Eligible participants were Japanese men and women who were prescribed a custom-made monobloc oral appliance (ASO International Inc, Tokyo, Japan) at the Sleep Apnea Dental Clinic in the Yoyogi Sleep Disorder Center, Tokyo, Japan, after a diagnosis of OSA between June 2005 and April 2013. Episodes of apnea and hypopnea were determined based on the American Academy of Sleep Medicine criteria of a reduction in airflow amplitude of >50% from baseline persisting for ⩾10 s in the presence of arousal or oxygen desaturation of at least 3% (Chicago criteria) [31].

Detailed information on the appliance and its adjustment protocol has been previously reported [26]. At their first visit to the clinic, 922 patients agreed that their polysomnography (PSG) results could be used for research and provided their written informed consent for the anonymous use of their data (Fig. 1). Patients who were prescribed titratable oral appliances ($n = 66$) and tongue-retaining ($n = 23$) or tongue-stabilizing devices ($n = 75$) were excluded [32–34]. Patients whose baseline AHI was <10 events per hour ($n = 81$) were not recruited, as these individuals could easily achieve each of the criterion for treatment success. Participants who did not undergo follow-up PSG because they were undergoing treatment or for other reasons were not recruited ($n = 453$). Consequently, 224 OSA participants were selected for analyses.

Treatment success was evaluated with the following response criteria. First responders were defined as patients who showed a reduction in AHI to <5 events per hour in addition to a >50% reduction in baseline AHI (criterion 1), which was selected because it has been recognized as an adequate cutoff point in avoiding adverse cardiovascular outcomes [35]. Criterion 2 was a follow-up AHI of <10 events per hour in conjunction with a >50% reduction in AHI at baseline and is one of the most frequently used criteria in the literature [2,3]. Criterion 3 was a >50% reduction in baseline AHI alone, which is a liberal and common definition of success [2,3]. Finally, a >50% reduction in baseline AHI with the nadir percutaneous oxygen (SpO_2) above 90% was defined as an adjunct criterion (criterion 4) to investigate the role of oxygenation on the success rate of treatment.

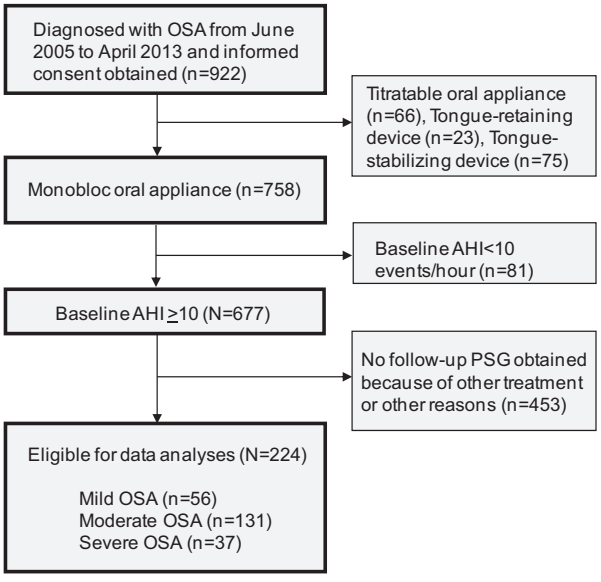

Fig. 1. Study flow diagram. *Abbreviations:* AHI, apnea hypopnea index; OSA, obstructive sleep apnea; PSG, polysomnography.

Paired *t* tests were used to compare the differences between the baseline and follow-up AHI (SPSS version 11.5, SPSS, Japan). In addition, the patients were divided into responders and nonresponders according to each response criterion. Unpaired *t* tests were used to examine the differences in AHI and nadir SpO_2 between responders and nonresponders. The effects of the severity of OSA at baseline (i.e., mild [AHI ⩾0–<15 events/h], moderate [AHI ⩾15–<30 events/h], and severe [AHI ⩾30 events/h] OSA subpopulations) on the success rate of treatment also were investigated. We used χ^2 tests on the 2×4 table followed by residual analyses to evaluate if the responder–nonresponder distributions differed depending on the responder criteria and the severity of OSA. A *P* value of <.05 was considered to indicate statistical significance.

3. Results

3.1. Overall characteristics of the participants

The baseline age and body mass index (BMI) in the 224 OSA participants was 47 ± 12 years and 25 ± 4 kg/m^2, respectively. The AHI at the initial diagnostic PSG was reduced with an oral appliance in place compared with the follow-up value (23 ± 11–8.5 ± 8.7 events/h; $P < .05$).

3.2. Mild OSA participants (AHI ⩾10–<15 events/h)

In mild OSA participants, the response rates differed among the four criteria ($\chi^2 = 9.1$; $P < .05$) (Table 1). There were no significant differences in the response rate (75%) among criteria 2, 3, and 4. The success rate was significantly reduced to 53% when criterion 1 was used ($|R_{adjusted}| = 3.0$; $P < .01$). Twelve of 42 responders (29%) under criteria 2, 3, and 4 did not satisfy criterion 1. The value of the nadir SpO_2 in responders was significantly improved with an oral appliance in place, and the follow-up value of SpO_2 exceeded 90% under each of the four response criteria.

3.3. Moderate OSA participants (AHI ⩾15–<30 events/h)

There was a statistically significant difference in the response rates among the four criteria ($\chi^2 = 34.2$; $P < .01$) in patients with moderate OSA. There were fewer responders under criterion 1 (40% $|R_{adjusted}| = 5.8$; $P < .01$) and more responders under criterion 3 (71% $|R_{adjusted}| = 2.5$; $P < .05$). There were 93 responders under criterion 3. However, 40 (43%), 5 (5%), and 3 (3%) of these responders did not satisfy criteria 1, 2, and 4, respectively. Similar to participants with mild OSA, the nadir SpO_2 in responders was significantly improved under each criterion.

3.4. Severe OSA patients (AHI ⩾30 events/h)

Severe OSA patients showed a lower success rate under criteria 1 (24% $|R_{adjusted}| = 2.2$; $P < .05$) and 4 (22% $|R_{adjusted}| = 2.6$; $P < .01$) and a higher success rate under criterion 3 (70% $|R_{adjusted}| = 4.3$; $P < .01$). Although 26 responders under criterion 3 showed a significant reduction in AHI ($P < .01$), 17 (65%), 10 (38%), and 18 (69%) of these responders were considered to be nonresponders under criteria 1, 2, and 4, respectively. Although both AHI ($P < .01$) and nadir SpO_2 ($P < .01$) were significantly improved under each of the four response criteria, the absolute increase in the nadir SpO_2 under criterion 3 was below 90% (87 ± 8%) after treatment.

Table 1
Effects of response criteria on treatment success with oral appliances and the percutaneous oxygen level in patients with obstructive sleep apnea.

	Criterion 1		Criterion 2		Criterion 3		Criterion 4	
	AHI<5 with 50%↑		AHI of <10 events/h with 50%↑		50%↑		50%↑ with nadir SpO_2 >90%	
	Responders	Nonresponders	Responders	Nonresponders	Responders	Nonresponders	Responders	Nonresponders
Total (*N* = 224)								
N (%)	92 (41)	132 (59)	146 (65)	78 (35)	161 (72)	63 (28)	140 (63)	84 (37)
B-AHI	20 ± 9	24 ± 13	21 ± 9	27 ± 15	23 ± 12	23 ± 11	20 ± 9	27 ± 13
F-AHI	2 ± 1*	13 ± 9*	4 ± 3*	17 ± 9*	5 ± 4*	18 ± 10*	3 ± 3*	15 ± 11*
B-nadir SpO_2	83 ± 8	80 ± 8	83 ± 8	80 ± 8	82 ± 9	81 ± 6	84 ± 7	79 ± 8
F-nadir SpO_2	93 ± 3*	84 ± 11*	91 ± 4*	81 ± 13	90 ± 6*	81 ± 14	93 ± 2*	83 ± 5*
Mild (*N* = 56)								
N (%)	30 (53)	26 (47)	42 (75)	14 (25)	42 (75)	14 (25)	42 (75)	14 (25)
B-AHI	13 ± 1	13 ± 1	13 ± 1	13 ± 1	13 ± 1	13 ± 1	13 ± 1	13 ± 1
F-AHI	2 ± 2**	9 ± 9	3 ± 2**	12 ± 11	3 ± 2**	12 ± 11	4 ± 3**	12 ± 17
B-nadir SpO_2	87 ± 4	86 ± 4	87 ± 4	86 ± 3	87 ± 4	86 ± 3	88 ± 3	85 ± 4
F-nadir SpO_2	92 ± 3**	89 ± 9	92 ± 3**	88 ± 3	92 ± 3**	88 ± 3	93 ± 2**	86 ± 2
Moderate (*N* = 131)								
N (%)	53 (40)	78 (60)	88 (67)	43 (33)	93 (71)	38 (29)	90 (69)	41 (31)
B-AHI	21 ± 4	20 ± 4	21 ± 4	21 ± 4	21 ± 4	21 ± 4	20 ± 4	22 ± 4
F-AHI	2 ± 2**	12 ± 8*	4 ± 3**	17 ± 8	4 ± 3**	17 ± 8	3 ± 2**	14 ± 10
B-nadir SpO_2	83 ± 7	80 ± 8	82 ± 8	79 ± 8	82 ± 8	80 ± 7	83 ± 7	78 ± 8
F-nadir SpO_2	93 ± 4**	82 ± 14	91 ± 5**	79 ± 17	90 ± 6**	79 ± 18	93 ± 3**	83 ± 5
Severe (*N* = 37)								
N (%)	9 (24)	28 (76)	16 (43)	21 (57)	26 (70)	11 (30)	8 (22)	29 (78)
B-AHI	40 ± 10	46 ± 12	41 ± 9	47 ± 13	45 ± 12	42 ± 10	38 ± 11	43 ± 9
F-AHI	2 ± 1**	18 ± 11**	4 ± 3**	22 ± 10**	8 ± 7**	28 ± 8**	1 ± 1**	17 ± 9
B-nadir SpO_2	77 ± 8	76 ± 9	75 ± 10	78 ± 7	75 ± 10	79 ± 5	75 ± 8	76 ± 10
F-nadir SpO_2	93 ± 2**	82 ± 6	91 ± 3**	81 ± 5	87 ± 8**	82 ± 3	93 ± 2**	82 ± 6

Abbreviations: h, hour; AHI, apnea–hypopnea index; B-, baseline; F-, follow-up; SpO_2, oxygen saturation.
Criterion 1 = a reduction in the AHI to <5 events/h and a >50% reduction from baseline; criterion 2 = follow-up AHI <10 events/h and a >50% reduction from baseline; criterion 3 = a reduction in AHI of >50%; criterion 4 = a reduction in AHI >50% with a nadir percutaneous SpO_2 level of >90%.
See text for detailed results of the χ^2 tests and the residual analyses.
* $P < .05$ vs baseline.
** $P < .01$ vs baseline.

4. Discussion

To our knowledge, our study is the first to demonstrate that the success rate of OSA treatment with an oral appliance can vary remarkably with selection of the response criteria. Notably a higher treatment success rate with less of an improvement in AHI (i.e., criterion 3) tended to provide an insufficient improvement in nadir SpO_2 as the severity of OSA increased. As suggested by Ferguson et al. [2], our findings emphasize the need to establish a uniform definition of treatment success that corresponds to a clear improvement in respiratory events and oxygenation.

The use of liberal response criteria may be somewhat appealing in a clinical setting, as this change would result in a better success rate of treatment according to a search of the literature on the outcome of treatment with oral appliances [13–30]. However, our results surprisingly revealed that 43% ([161–92]/161 × 100), 9% ([161–146]/161 × 100), and 13% ([161–140]/161 × 100) of the overall responders under criterion 3 were considered to be nonresponders under criteria 1, 2, and criterion 4, respectively, among the 224 subjects. This trend was particularly pronounced in severe OSA patients. If we consider that even mild AHI is a pathologic condition which may be associated with an increased cardiovascular risk, some patients with a residual AHI after oral appliance treatment could still be exposed to the risk for an adverse cardiovascular consequence including OSA-related hypoxemia [35,36]. We speculate that the discrepancy between statistically significant and clinically relevant outcomes needs to be more generally recognized in oral appliance therapy and perhaps other modalities overall. Based on our results, the selection of criterion 3 in conjunction with a follow-up nadir SpO_2 of more than 90% (i.e., criterion 4) rather than criterion 3 alone may be an appropriate definition of treatment success in oral appliance therapy, especially for patients with severe OSA.

5. Conclusion

Selection of the response criteria influences the success rate of treatment with oral appliances. Treatment success evaluated with liberal response criteria in patients with more severe OSA should be interpreted with caution in light of an insufficient restoration of oxygenation which is associated with elevated residual respiratory events. To better define treatment success, the use of changes in oxygenation as an adjunct parameter to AHI may be reasonable for avoiding adverse health outcomes, especially in patients with more severe OSA.

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Conflict of interest

The ICMJE Uniform Disclosure Form for Potential Conflicts of Interest associated with this article can be viewed by clicking on the following link: http://dx.doi.org/10.1016/j.sleep.2013.12.007.

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